freely with the second centrum, and that the diapophyses of the second vertebra are not partly below the præzygapophyses, as in all Cryptodira, but entirely behind; in all these respects agreeing with the vertebræ of *Podocnemis madagascariensis* figured above. Two adult skeletons of *Testudo polyphemus* are in the Museum; they do not show the slightest resemblance to *Miolania* in their first and second vertebræ, and, in addition to their position, the diapophyses of the latter differ in not being half so much developed.

Dr. Baur wonders "how Mr. Boulenger could compare the cervicals of *Miolania* with those of *Chelys*." He misinterprets the meaning of my words :—"The cervical vertebræ [of *Miolania*] are those of a Pleurodiran; a strong and long transverse process is present, and the posterior borders of the odontoid bone and of the second centrum are deeply emarginate inferiorly, terminating in two diverging processes, as in *Chelys*."

If Dr. Baur were acquainted with the structure of the hyoid in the Pelomedusidæ he could not have pointed to the character of the hyoid bones as proving the Testudinoid nature of *Miolania*.

XVI.—*The new Flora of Krakatao.* By M. Treub*.

Averse though I am to preliminary communications †, I feel compelled to make an exception in the present instance, and this for two reasons. First, because absolutely nothing is known of the manner in which a volcanic island becomes clothed with an entirely new vegetation; secondly, because the data which I am able to furnish on the new flora of Krakatao are definitely acquired at the present time; there is no fear of their being invalidated by subsequent researches.

It is owing to the kindness of M. R. D. M. Verbeek, chief engineer of mines, a learned geologist and the well-known historiographer of the eruption of Krakatao, that I have been

* Translated from the 'Archives des sciences physiques et naturelles,' Dec. 15, 1888.

† This notice contains an abstract of a communication made by the author to the Academy of Sciences of Amsterdam at its meeting of the 28th January, 1888. "I intend to visit Krakatao again, in company with my friend Dr. W. Burck. I hope that we shall be able in time to publish a work in detail on the new flora of the island."

able to visit the island, nearly three years after it had been the theatre of the terrible calamity.

The information concerning Krakatao obtained from navigators about this period left doubts existing on the question essentially interesting to botanists, namely whether the island again showed a commencement of vegetation. Some maintained that the thick layer of pumice-stone which covers it was bare and everywhere barren. Others affirmed, on the contrary, that they had distinctly recognized plants of some height, here and there, by the aid of telescopes.

When we drew near to Krakatao on the morning of the 19th of June, 1886, we were not long in distinguishing a fair number of plants; and this not only near the sea-level, but likewise on the heights and even towards the summit of the island.

It is necessary to say in this place that the existing island —that is to say, the part which has remained after the eruption *—has the form of a mountain standing by itself in the sea, rising on one side almost perpendicularly to an altitude of about 2500 feet. The slopes of the opposite side are much more inclined, but nevertheless fairly precipitous. The beach is very narrow; at the foot of the huge, almost perpendicular wall there is none at all.

Before enumerating the plants which I have found at Krakatao, and before entering into any discussion on the subject of this new flora, we must first of all briefly consider two points.

In the first place it is indispensable to prove that the existing flora must be regarded as new and that it has not arisen from the remains of the luxuriant vegetation which covered the island before the eruption. Nothing is easier, however, than to furnish this proof. At the time of the eruption the trees, thrown down or broken by the violent gusts of wind, must have been half carbonized, considering the extremely high temperature which undoubtedly prevailed over the whole island.

Afterwards Krakatao was covered from the summit to well below the sea-level with a layer of ashes and of burning pumice. This layer has a thickness varying from 1 to 60 metres. Under such conditions it is clear that no vestige of the flora could have existed after the cataclysm. The most persistent seed and the best protected rhizome must have for ever lost all vitality.

* The great eruption of Krakatao took place from the 26th to 28th of August, 1883.

There is no need to discuss the possibility of the plants newly installed at Krakatao having been brought there by the intermediation of man. The island is uninhabited, uninhabitable, and difficult of access.

Finally, the composition itself of the existing flora of Krakatao is an additional proof that it cannot have derived its origin either from the former flora or by the intervention of man.

In the second place I think it necessary to say a few words on the views generally adopted as to the origin of the floras of islands. This question, justly regarded as one of the most important in botanical geography, has been treated in a number of works and memoirs of great value. It would be out of place in this short notice to make numerous quotations; nevertheless I cannot refrain from mentioning the excellent memoirs on insular floras and their origin published two years ago by Mr. W. Botting Hemsley of Kew. In these memoirs, which together form the first volume of the "Botany" part of the celebrated 'Challenger' Reports, Mr. Hemsley has brought together and discussed all the data bearing on the subject.

Everything to be found in literature on the origin of insular floras has reference to coral-islands: these are the only ones for which direct observations have been possible up to the present time.

When one of these islands has begun to rise above the level of the sea, seeds carried by ocean-currents from distant shores strike against the growing island. Arrested for good and all in their passive course these seeds germinate and give birth to the first vegetation of the island. That seeds and fruits may play this *rôle* of first colonizing agent they must be able to float for a long time in the sea and must not lose their germinative power. These two qualities being rarely united, the number of plants which land on one of these new coral-islands is very restricted. It is always the same plants, generally trees, to which the *rôle* of first colonizing agent reverts; there are at the most thirty species in all which come under consideration.

Once the isle is provided with some trees a second colonizing agent intervenes. It is birds, and amongst them especially oceanic pigeons (frequently *Carpophaga oceanica*), which now act this *rôle*, by coming to rest on the trees after their long flight. Being frugivorous, they deposit on the island with their excrement the seeds of many plants, which are not long in constituting a new and important element of this flora *in statu nascendi*. Ocean-currents and birds are thus the two agents

to which newly emerged coral-islands are indebted for their floras. The wind or fortuitous causes may bring spores or seeds of other plants later on ; but these latter will then find the soil prepared by their predecessors brought by the sea or by birds.

Now, how does a lofty volcanic island, a mountain which has sprung suddenly out of the sea at the time of an eruption, clothe itself with plants? Or, which comes to the same thing for the botanist, How does a volcano forming an island, having lost all its vegetation by an eruption, acquire a new flora? These questions have never been put in a categorical manner so far as I know. It is not to be wondered at, since only quite hypothetical answers could have been given.

Nobody up to the present time has been in the position of witnessing the advent of a new flora on a volcanic island.

After the knowledge acquired on the origin of coral-island floras I do not think I shall be deviating too far from the truth in assuming that the advent of a flora on one of these volcanic islands should be depicted in the following manner. The littoral of the island becomes covered with plants by the aid of seeds brought by ocean-currents and by birds in just the same manner as with coral-islands. The elements which compose the flora of this littoral belt will ascend little by little the slopes of the island ; this is possible, since the majority of these plants, although preferring a saline station, yet grow vigorously at a distance from the shore and at a tolerably great altitude. However, the further the original vegetable belt of the shore ascends, the more its progress slackens. Lastly, it will be almost entirely by the mediation of birds that the most elevated parts of the island will be stocked with plants. When once the whole island is covered with a vegetable carpet, as yet not very dense, the soil will be prepared little by little for the reception of other plants, the spores or the seeds of which are brought by the wind or by other agents.

Let us now return to Krakatao to see what we learn from the reality.

It is clear, after all that has been said, that a distinction must be made between the flora of the shore and that of the mountain proper, since we already know that there are plants on Krakatao up to an altitude of more than 2000 feet.

I visited Krakatao on two occasions between the 19th and 24th June, 1886. On the shore I collected seeds or fruits of the following plants :—

Heritiera littoralis, *Dryand.* (1).
Terminalia catappa, *L.* (2).
Cocos succifera, *L.* (1).
Barringtonia speciosa, *L.* (5).
Calophyllum inophyllum, *L.* (3).
Pandanus, sp. (1).

The figures after the name of the plants indicate the number of fruits and seeds collected. Subsequently I found on the shore some young shoots of the following species :—

Erythrina, sp.
Calophyllum inophyllum, *L.*
Cerbera odallam, *Gaertn.*
Hernandia sonora, *L.*
Two Cyperaceæ.
Ipomœa pes-capræ, *Sw.*
Gymnothrix elegans, *Büse.*
Scævola Kœnigii, *Vahl.*

As was to be supposed, all the plants and seeds met with on the littoral of Krakatao, with the exception of *Gymnothrix elegans*, a grass common in Java, belong to the list of species which stock newly emerged coral-islands.

In the interior of the island, upon the mountain proper, I found the following species :—

Phanerogams.

Wollastonia, sp.
Two species of *Conyza.*
Senecio, sp.
Scævola Kœnigii, *Vahl.*
Gymnothrix elegans, *Büse.*
Phragmites Roxburghii, *N. ab E.*
Tournefortia argentea, *L.*

Ferns.

Gymnogramme calomelanos, *Kaulf.*
Blechnum orientale, *L.*
Acrostichum scandens, *J. Sm.*
—— aureum, *Cav.*
Pteris longifolia, *L.*
Nephrolepis exaltata, *Schott.*
Nephrodium calcaratum, *Hook.*
—— flaccidum, *Hook.*
Pteris aquilina, *L.*, var.
—— marginata, *Bory.*
Onychium auratum, *Kaulf.*

The determination of the Ferns is due to the kindness of Dr. W. Burck.

The list gives rise to the following observations.

First, it is seen that the new flora of the interior of Krakatao * is entirely different from that of the littoral, since there are only two species met with both on the shore and the mountain. Then the presence of four species of Compositæ merits notice. It can hardly be doubted that their seeds have been carried to Krakatao by the wind, contrary to the opinion generally held in botanical geography, according to which the seeds of Compositæ have hardly ever been known to be

* I also found two mosses on Krakatao. Having sent them to Dr. v. d. Sande Lacoste at Amsterdam with a request that he would determine them, I hoped to learn their names on my return to Europe. On arriving in Holland I became acquainted with the sad news of the death of Dr. v. d. Sande Lacoste, which had taken place during my voyage to Europe. It will be sufficient to state here that the two mosses in question do not play any important part in the restocking of Krakatao.

transported by the wind across an arm of the sea, even though very narrow *.

Lastly, the great number of species of ferns constitutes the most interesting result of the inquiry. Amongst these eleven species of ferns there are only two, *Acrostichum aureum* and *Nephrolepis exaltata*, which are widely distributed over the islands of the hot regions. For these two species, which probably prefer a soil more or less impregnated with saline matters, Krakatao can offer some advantages in this respect; for the nine other species this is not the case.

But more than that. In order to judge of the relative importance of plants belonging to different groups in the re-stocking of a country, the point in question in the first place is not the number of species but the number of individuals. Looking at it from this point of view, I can formulate the result of the inquiry made at Krakatao thus:—

Three years after the eruption the new flora of Krakatao was composed almost entirely of Ferns. The Phanerogams were only found isolated, here and there on the shore or on the mountain itself.

It is therefore ferns to which the *rôle* reverts of preparing the earth for the phanerogamic vegetation, which in time will cover the island again as it covered it before the eruption.

There is nothing at all astonishing in the fact that numerous spores of ferns fall on Krakatao, since the wind carries even the seeds of phanerogams over the island; but what is almost incomprehensible to any one on the spot is how the ferns and their prothallia succeed in living under such disadvantageous conditions. Chemically and physically the volcanic matter which covers Krakatao constitutes one of the most arid of soils. To give an idea of the chemical composition presented to plants by this substratum, I reproduce the result of two analyses according to M. Verbeek †:—

	No. 7 *a*.	No. 9 *a*.
SiO_2	61·36	68·99
TiO_2	1·12	0·82
Al_2O_3	17·77	16·07
Fe_2O_3	4·39	2·63
FeO	1·71	1·10
MnO	0·41	0·28
CaO	3·43	3·16
MgO	2·32	1·08
K_2O	2·51	1·83
Na_2O	4·98	4·04

* The distances of Krakatao from Sibesia, Sumatra, and Java are 10, 20, and 21 miles. The two small islands "Lang eiland" and "Verlaten eiland," which were completely laid waste at the time of the eruption, were absolutely uninhabited at the period of my visit to Krakatao.

† R. D. M. Verbeek, 'Krakatao,' Batavia, 1885–86, p. 309.

M. Verbeek adds: "the dark-coloured ash no. 7 *a* is probably the most basic, the pumice no. 9 *a* the most acid product of those cast out by Krakatao in 1883." It has been said of the island of Ascension that the soil resembles powdered glass. It is clear that the same thing might be said of Krakatao.

As for the physical conditions, the pumice-stone and the greyish-coloured ashes which cover Krakatao are continually heated by a scorching sun, without there being any trace of shade.

With the assistance of my friend Dr. Burck I made, in the laboratory of the garden at Buitenzorg, sowings of the fern-spores brought back from Krakatao on all kinds of substratum. We wished to see whether the prothallia and young plants of these ferns presented any special adaptations which would enable them to overcome conditions so little favourable as those offered by the soil of Krakatao. During an examination which was of necessity brief * nothing revealed the presence of special adaptations either in the prothallia or in the young plants.

To the mind of one verifying on the spot the predominance of ferns at Krakatao the following questions immediately present themselves. How can the fern-spores germinate under such conditions? are there not plants of a lower order there, which cover the pumice-stone and the ash with a thin layer, enabling the spores to germinate? In the first place I thought of small lichens; but I did not succeed in finding a single lichen on the whole island. But here and there on the surface of the ash and of the pumice a glaucous or greenish layer could be distinguished, which evidently arose from Algæ. A minute examination with the lens showed that the same thing existed nearly everywhere, though in a less pronounced degree. I then collected samples of the superficial layer of the soil of Krakatao from several places in order to examine them at Buitenzorg.

It appears that the ash and the pumice composing the soil of Krakatao are covered almost everywhere with a thin layer of Confervoid Algæ.

I have proved the presence on Krakatao of six species of these Confervoid Algæ, to wit: one *Tolypothrix*, one *Anabæna*, one *Symploca*, and three species of *Lyngbya*. I shall distinguish provisionally the last three species by the following names:—

* In consequence of the indisposition which compelled me to return for some time to Europe.

Lyngbya Verbeekiana, thickness without sheaths from 1·9 to 3·4 μ, with sheaths from 5 to 6·8 μ.

Lyngbya minutissima, maximum thickness, without sheaths 1·03 μ, with sheaths 1·38 μ.

Lyngbya intermedia, thickness without sheaths from 1·73 to 3·45 μ, with sheaths from 1·73 to 3·45 μ*.

By far the most common of these species is *Lyngbya Verbeekiana*; next comes *Lyngbya minutissima*. These two Algæ very frequently emerge from their sheaths.

Thanks to these six species of Algæ and to their empty sheaths, especially of the two *Lyngbyæ* I have just mentioned, the arid soil of Krakatao is covered with a thin gelatinous and hygroscopic layer. There is no doubt in my mind that the presence of this layer alone enables the spores of the ferns and of mosses to germinate. On one of the samples of the soil of Krakatao I found a spore of *Pteris longifolia* with a germinative filament of three cells imprisoned in a network of sheaths of *Lyngbya Verbeekiana*.

The Algæ prepare the earth for the Ferns in some such manner as the latter do in their turn for the Phanerogams.

Let us now suppose for an instant that Krakatao, instead of being only a score of miles from Java and from Sumatra, was isolated in the sea at a very great distance from all plant-bearing land. What would take place? The belt of phanerogams installed on the littoral of the island would climb the mountain up to a certain height, driving back the ferns. This progress would only be arrested at an altitude which no longer suited the elements of the littoral flora. Considering the isolation of the island, the seeds of other phanerogams, fitted for existence at greater altitudes, would never or hardly ever arrive at this station lost in the ocean. Consequently the ferns would retain their predominance for all time in the higher regions of the island, in company perhaps with some Lycopods, and the phanerogams would remain restricted to the lower regions and to the shore.

What we have just supposed for Krakatao is realized in the cases of Juan Fernandez and Ascension.

Juan Fernandez, a small volcanic island, is situated 400 miles from the coast of Chili. Mr. Moseley says of its flora:—"There are upwards of twenty-four species of ferns growing in this small island, and in any general view the ferns form a large proportion of the main mass of vegetation."

Ascension, an entirely volcanic island of about the same height as Krakatao, has a soil which has been described thus:—"St. Helena has been called a barren rock, but it is a

* So in the original.—Eds. 'Annals.'

paradise as compared with Ascension, which consists of a scorched mass of volcanic matter in part resembling bottle-glass and in part coke and cinders." In his 'Lecture on Insular Floras' Sir Joseph Hooker expresses himself in the following manner on the island and the vegetation which covers it:—"A small green peak, 2800 feet above the sea, monopolizes nearly all the vegetation, which consists of Purslane, a grass, and a Euphorbia in the lower parts of the island, whilst the green peak *is clothed with a carpet of ferns*, and here and there a shrub."

I have been led to add these data on Juan Fernandez and Ascension to show that the facts established for Krakatao do not constitute an exception.

I think, finally, that I am therefore justified in stating that:

During the advent of a new flora on a volcanic island which is under the same conditions as Krakatao, the Phanerogams will always be preceded by Ferns, and this doubtless owing to the less physiological differentiation of the latter.

After an island—or a portion of a continent—has been devastated by an eruption and covered with volcanic matter, the vascular Cryptogams—and especially the Ferns—still perform at the present day the same part which they very frequently did in the remote periods when they predominated on the earth's surface.

Voorschoten,
March 3, 1888.

XVII.—Nototherium *and* Zygomaturus.

By R. Lydekker, B.A., F.G.S.

In a short paper recently published in the Proc. R. Soc. Queensland, vol. v. pp. 111–116, and plate, Mr. C. W. De Vis again raises the question whether the humerus referred by Sir R. Owen to *Nototherium* is rightly determined *.

This time, however, a new point of departure is taken. It may be observed in passing that Mr. De Vis starts the untenable proposition that the type of *Nototherium* being imperfect cannot be taken as the real type of the genus: but since this does not affect the question he has raised it need not be further mentioned. The gist of his contention is that the

* De Vis, Proc. Linn. Soc. N. S. Wales, vol. viii. p. 404. See also Lydekker, Cat. Foss. Mamm. Brit. Mus. pt. v. p. 161.